

Stoichiometry

Name: _____

AP Chemistry Lecture Outline

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Chemical Equations

In a reaction:

AND

Balancing Chemical Equations

Hint: Start with most complicated substances first and leave simplest substances for last.

EX. Solid lithium reacts w/oxygen to form solid lithium oxide.

EX. Aqueous aluminum sulfate reacts w/aqueous barium chloride to form a white precipitate of barium sulfate. The other compound remains in solution.

EX. Methane gas (CH₄) reacts with oxygen to form carbon dioxide gas and water vapor.

EX. $\text{CaC}_2(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_2\text{H}_2(\text{g}) + \text{CaO}(\text{s})$

$\text{CaSi}_2 + \text{SbI}_3 \rightarrow \text{Si} + \text{Sb} + \text{CaI}_2$

$\text{Al} + \text{CH}_3\text{OH} \rightarrow \text{Al}(\text{CH}_3\text{O})_3 + \text{H}_2$

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$\text{C}_2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

$\text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

$\text{C}_4\text{H}_{10} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

Complete combustion of a hydrocarbon, or of a compound containing C, H, and O (e.g., methanol, CH₃OH) yields CO₂ and H₂O.

Another pattern of reactivity: alkali metal + water \longrightarrow metal hydroxide + hydrogen gas
e.g.,

Two (of the several) Types of Reactions

combination (synthesis): simpler substances combine to form more complex substances

-- form:

EX. sodium + chlorine gas \rightarrow sodium chloride

decomposition: complex substances are broken down into simpler ones

-- form:

EX. lithium chlorate \rightarrow lithium chloride + oxygen

EX. water \rightarrow hydrogen gas + oxygen gas

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formula weight: the mass of all of the atoms in a chemical formula (unit is amu)

-- If the substance is a molecular substance (e.g., C_3H_8), then the term

molecular weight is also used.

molar mass: the mass of one mole of a substance (unit is usually grams)

-- recall that 1 mole of any substance = 6.02×10^{23} particles of that substance

EX. Find the molar mass and formula weight of ammonium phosphate.

percentage composition: the mass % of each element in a compound

-- equation:

EX. Find the percentage of oxygen, by mass, in calcium nitrate.

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Empirical Formula and Molecular Formula

Compound	Molecular Formula	Empirical Formula
glucose	$C_6H_{12}O_6$	
propane	C_3H_8	
butane	C_4H_{10}	
naphthalene	$C_{10}H_8$	
sucrose	$C_{12}H_{22}O_{11}$	
octane	C_8H_{18}	

Finding an Empirical Formula from Experimental Data

1. Find # of g of each element.
2. Convert each g to mol.
3. Divide each "# of mol" by the smallest "# of mol."
4. Use ratio to find formula.

EX. A ruthenium/sulfur compound is 67.7% Ru. Find its empirical formula.

EX. A sample of a compound contains 4.63 g lead, 1.25 g nitrogen, and 2.87 g oxygen.
Name the compound.

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To find molecular formula...

- A. Find empirical formula.
- B. Find molar mass of empirical formula.
- C. Find $n = \frac{mm \text{ molecular}}{mm \text{ empirical}}$
- D. Multiply all parts of empirical formula by n.

EX. A sample of a compound has 26.33 g nitrogen, 60.20 g oxygen, and molar mass 92 g. Find molecular formula.

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Hydrates and Anhydrous Salts

anhydrous salt: an ionic compound (i.e., a salt) that attracts water molecules and forms weak chemical bonds with them; symbolized by MN
 “anhydrous” =
 Same idea as with...

hydrate: an anhydrous salt with the water attached

-- symbolized by MN · ? H₂O

Examples:



Finding the Formula of a Hydrate

1. Find the # of g of MN and # of g of H₂O.
2. Convert g to mol.
3. Divide each “# of mol” by the smallest “# of mol.”
4. Use the ratio to find the hydrate’s formula.

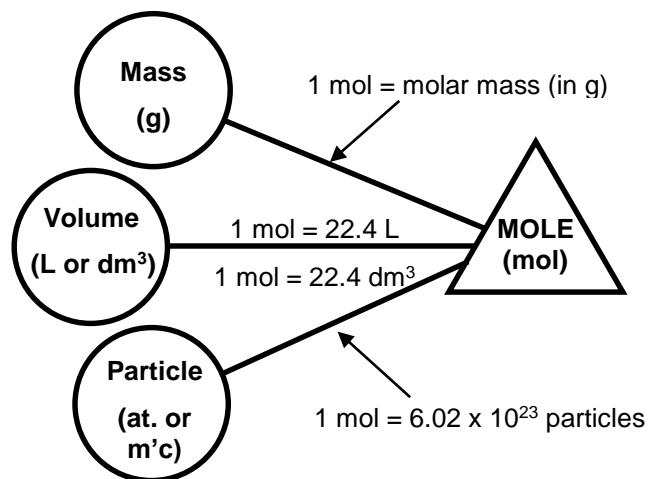
EX. Strontium chloride is an anhydrous salt on which the following data were collected. Find formula of hydrate.

beaker = 65.2 g
beaker + sample before heating = 187.9 g
beaker + sample after heating = 138.2 g

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Converting Between Various Units

“Volume Island”: for gases only
1 mol @ STP = 22.4 L = 22.4 dm³



EX. What mass is 6.29×10^{24} molecules of aluminum sulfate?

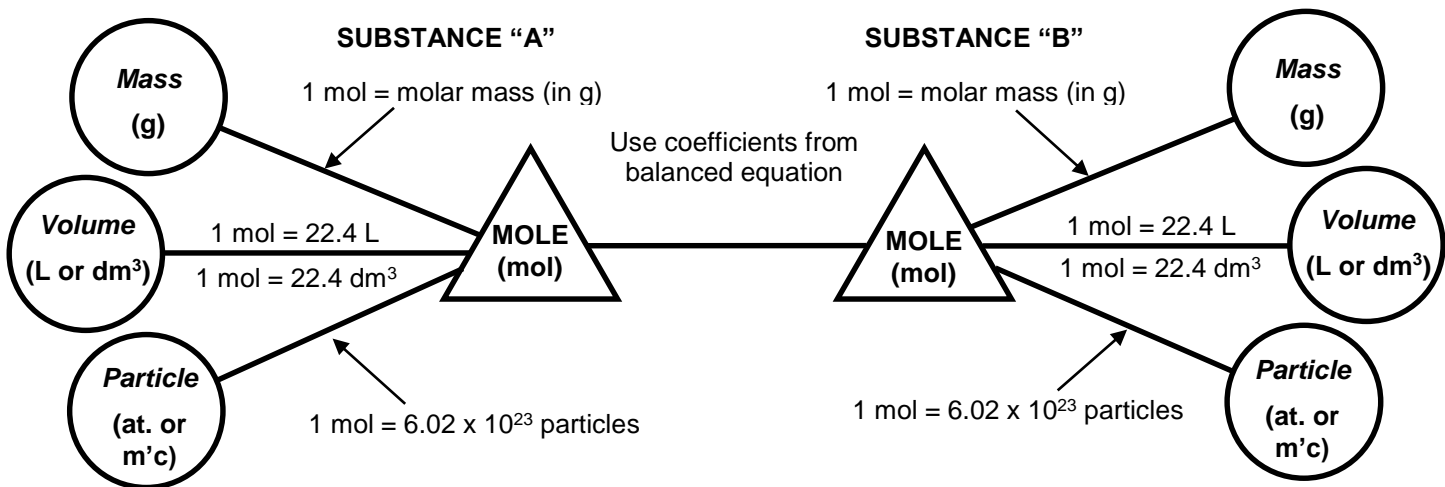
EX. At STP, how many g is 87.3 dm³ of nitrogen gas?

When going from moles of one substance to moles of another, use the coefficients from the balanced equation.

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**“Straight”
Stoichiometry**

Stoichiometry Island Diagram



EX. How many moles oxygen will react with 16.8 moles sodium?

EX. How many grams potassium will react with 465 grams nickel(II) phosphide?

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At STP, how many molecules of oxygen react with 632 dm³ of butane (C₄H₁₀)?

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Limiting Reactants (a.k.a., Limiting Reagents)

limiting reactant (LR): the reactant that runs out first

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Any reactant you don't run out of is an excess reactant (ER).

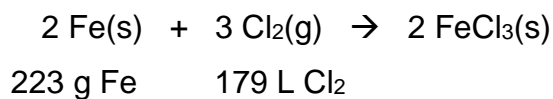
How to Find the Limiting Reactant

For the generic reaction $R_A + R_B \rightarrow P$, assume that the amounts of R_A and R_B are given. Should you use R_A or R_B in your calculations?

1. Calc. # of mol of R_A and R_B you have.
2. Divide by the respective coefficients in balanced equation.
3. Reactant having the smaller result is the LR.

EX. $2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{g})$
13 g H_2 80. g O_2 How many g H_2O are formed?

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At STP, what is the limiting reactant?

What mass of FeCl_3 is produced?

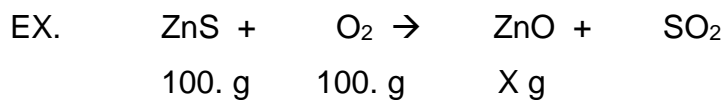
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Theoretical Yield, Actual Yield, and Percent Yield

The amount of product we get if the reaction is perfect is called the theoretical yield.

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If we ACTUALLY DO the reaction and measure the actual yield, we will find that this amount is less than the theoretical yield (i.e., % yield can never be > 100%).



Assume 81% yield.

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Automobile air bags inflate with nitrogen via the decomposition of sodium azide:



At STP and a % yield of 85%, what mass sodium azide is needed to yield 74 L nitrogen?